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Ultrasonography in emergency service, evaluation of central venous catheterization

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Abstract
Aim: In this study, we aimed to compare patients who underwent anatomic landmarks guided or ultrasound (USG) guided central venous catheterization (CVC) in terms of success rates and complications.
Material and Methods: A total of 220 patients were included in the study. Patients were divided into two groups as follows: Group U consisted of patients who underwent USG guided CVC procedure, and Group A consisted of patients who underwent CVC anatomic landmarks guided. Demographic data, CVC procedure technic, complications, and time to successful catheterization were recorded.
Results: The results showed a statistically significant difference; the length was less than 20 minutes in Group U. CVC-related complications and the mortality rate were significantly higher in Group A (p<0,01). In the analysis of all the CVCs independently from the location, the jugular vein was most preferred for the central cannulation in both landmarked and USG-guided techniques with a rate of approximately 94 % and 42 %, respectively (p<0,01).
Discussion: We found a significant increase in the success rate and a significant decrease in the complications rate and intervention duration when the USG-guided technique was preferred for central vein cannulation compared with the landmark technique. When USG is available, USG-guided procedure should become the standard for cannulation procedure in ED.

Keywords
Catheterization; Central venous; Emergency services; Ultrasonography

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Introduction

Central venous catheterization (CVC) is a widely used procedure in emergency departments to provide temporary or long-term vascular access. The most common indications for CVCs are as follows: hemodynamic monitoring, long-term fluid therapy, delivery of blood products or drugs (for example, chemotherapy and antibiotics), hemodialysis, an internal pacemaker need [1]. Also, CVC is a life-saving procedure for patients with vascular access failure. Another reason to prefer CVC for peripheral veins is that CVCs are less likely to collapse or occlude with thrombus. Consequently, catheterization may provide a more long-term line.

CVC is an invasive procedure that is not without complication, the most common of which are air embolism, pneumothorax, arterial injury, arrhythmia, and infection [1]. Complications of the central catheter are associated with many factors, such as patient-related factors, the side of intervention, the experience of the physician [2]. The literature reports that ultrasound-guided cannulation increases the success of the procedure and reduces the complication [1, 3]. Average cost, lack of education, and experience to use ultrasounds are the common reasons for less use of ultrasound [1, 4].

Peripheral venous catheterization should not be performed if there is cellulitis or burns on the extremities, or if there is a severe acute injury to the distal or drainage site of the extremity [1]. Hyperosmolar fluids and agents are known to cause chemical phlebitis, or sclerosis should not be administered by infusion through peripheral veins. In such cases, central venous catheterization is indispensable for treatment. The success of the central catheterization procedure depends on the anatomic region, the method applied, and the physician is performing the procedure. Complications may occur during or after the procedure. Mechanical, thrombotic, and infection-related complications may develop. Catheter malfunction, catheter breakage, air embolism, pneumothorax, arterial or nerve damage, arrhythmia, hemorrhage, sepsis are the most common [2].

The most common method used for catheter insertion is to follow the anatomical pathway, but the literature reports more serial USG-guided catheters interventions and fewer complications [1]. In most cases,, many challenges arise during the anatomic landmarks guided procedure, such as short neck and suspected cervical trauma. In such situations, ultrasound-guided interventions are preferred to avoid patient movement and to achieve desired images. Besides, a portable USG device can be used to check whether the inserted catheter is in the vessel wall or at the bedside. Using this method in medical centers with USG devices reduces the number of interventions and, therefore, reduces the cost of follow-up and treatment of complications [2].

In this study, we aimed to compare patients who underwent anatomic landmarks guided or USG-guided central venous catheterization in terms of success rates and complications.

Material and Methods

Data extraction and the participants

Data were collected from the hospital database. Data of all the patients scheduled for central venous access in the ED during a year (January 01, 2012- March 30, 2013) were included. The patients with a lack of data, patients under 15 years of age, patients who were admitted from another hospital with already inserted CVC, patients who were referred to another hospital for further follow-up were excluded from the study.

Local ethics committee approval was obtained (number: HNEAH-KAEK 2013/70). Totally 220 patients out of 1300 were enrolled. The procedure selection was up to the physicians' experience. Demographic data, number of interventions, CVC procedure technic, and complications were recorded. Data related to processes included vein preferred for the catheter placement (internal jugular, subclavian or femoral), measurement of the central venous diameter, number of attempts to successful catheterization, and time (minutes) to successful catheterization. Patients were divided into two groups as follows: Group U consisted of patients who underwent CVC procedure ultrasound-guided (B-mode USG), and Group A consisted of patients who underwent catheterization anatomic landmarks guided.

Data analyses

NCSS (Number Cruncher Statistical System), 2007 & PASS (Power Analysis and Sample Size), 2008 Statistical Software (Utah, USA) program was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, frequency, ratio) were used to evaluate the data, and the Student t-test was used to compare normal distribution parameters. Pearson's chi-square test, Yates Continuity Correction, and Fisher's Exact test were used to analyze qualitative data. The results were evaluated with a 95% confidence interval and a significance level of $p < 0.05$.

Results

A total of 220 patients were included in the study. The ages of the patients were between 15 and 100 years; the average age was 67,29±20,16 years; %41,4 (n=91) of the patients were female, %58,6 (n=129) were male.

We investigated the ultrasound-guided and anatomic landmark guided catheter insertion attempts according to indications. The patients with hypovolemia, cardiopulmonary arrest, and the need for hemodynamic monitorization, significantly less underwent ultrasound-guided CVC ($p<0,01$). The patients with acute kidney injury and those who needed catheterization for hemodialysis significantly more underwent ultrasound-guided CVC ($p<0,01$).

We analyzed the preference of the central vein catheterization technique based on catheter localization. Ultrasound-guided central vein catheterization was significantly more preferred for jugular vein catheterizing ($p<0,05$). Table 1 shows the indications and the preferences of CVC technics according to the vein localization in detail.

We compared the durations for catheter insertion and the number of attempts, distinguished between the two groups. The results showed a statistically significant difference ($p < 0.05$); the length was less than 20 minutes in Group U, and longer in Group A. Again, trial success was better in Group U compared to the Group A. Table 2 shows the duration of catheter insertion and the number of trials between the groups in detail.

We analyzed the catheter-related complications.

Table 1. Distribution of CVC indications and the techniques preferred for catheterization

Indications	Total	Group A	Group U	P
	N= 220 (%)	N= 171 (%)	N= 49 (%)	
TPN	12 (%5,5)	12 (%7,0)	0 (%0,0)	[d]0,073
CVP Measurement	57 (%25,9)	51 (%29,8)	6 (%12,2)	[c]0,022*
Hypovolemia	67 (%30,5)	61 (%35,7)	6 (%12,2)	[c]0,003**
Monitoring	98 (%44,5)	85 (%49,7)	13 (%26,5)	[c]0,007**
Cardiopulmonary Arrest	56 (%25,5)	53 (%31,0)	3 (%6,1)	[c]0,001**
Acute Renal Failure	89 (%40,5)	59 (%34,5)	30 (%61,2)	[b]0,001**
Hemodialysis	107 (%48,6)	75 (%43,9)	32 (%65,3)	[b]0,008**
Vasculer access is not possible	46 (%20,9)	35 (%20,5)	11 (%22,4)	[c]0,919
Long-term IV therapy	75 (%34,1)	61 (%35,7)	14 (%28,6)	[c]0,451
Trauma	17 (%7,7)	13 (%7,6)	4 (%8,2)	[d]1,000
Catheter location				
Juguler	118 (%53,6)	72 (%42,1)	46 (%93,9)	[c]0,001**
Femoral	28 (%12,7)	28 (%16,4)	0 (%0,0)	[c]0,005**
Subclavian	74 (%33,6)	71 (%41,5)	3 (%6,1)	[c]0,001**

[b]Pearson Chi-Square [c]Yates Continuity Correction [d]Fisher's Exact Test *p<0,05 **p<0,01
Group A: Anatomic landmark-guided group, Group U: Ultrasound-guided group,
TPN: total parenteral nutrition, CVP: central vein pressure

Table 2. Comparison of catheter insertion time and the number of attempts between the groups

Complications		Number of Attempts			
		Total	Group A	Group U	P
		N= 220 (%)	N= 171 (%)	N= 49 (%)	
Catheter Insertion Duration	> 20 Min.	113 (%51,4)	106 (%62,0)	7 (%14,3)	[c]0,001**
	< 20 Min.	107 (%48,6)	65 (%38,0)	42 (%85,7)	
Number of Attempts	1st Attempt	98 (%44,5)	52 (%30,4)	46 (%93,9)	[c]0,001**
	2nd Attempt	84 (%38,2)	81 (%47,4)	3 (%6,1)	[c]0,001**
	>More than two attempts	38 (%17,3)	38 (%22,2)	0 (%0,0)	[c]0,001**

[c]Yates Continuity Correction **p<0,01
Group A: Anatomic landmark-guided group, Group U: Ultrasound-guided group

Table 3. Assessment of catheter-related complications according to ultrasound guide utilization

Complications	Total	Group A	Group U	P
	N= 220 (%)	N= 171 (%)	N= 49 (%)	
Arterial Interference	2 (%0,9)	2 (%1,7)	0 (%0,0)	[d]1,000
Perforation	1 (%0,5)	1 (%0,6)	0 (%0,0)	[d]1,000
Arrhythmia	17 (%7,7)	17 (%9,9)	0 (%0,0)	[d]0,015*
Dislocation	1 (%0,5)	1 (%0,6)	0 (%0,0)	[d]1,000
Thrombosis	18 (%8,2)	18 (%10,5)	0 (%0,0)	[d]0,015*
Infection	33 (%15,0)	33 (%19,3)	0 (%0,0)	[c]0,002**
False Intervention	3 (%1,4)	3 (%1,8)	0 (%0,0)	[d]1,000
Obstructed Vein	19 (%8,6)	19 (%11,1)	0 (%0,0)	[d]0,009**
Ex	46 (%20,9)	45 (%26,3)	1 (%2,0)	[c]0,001**

[c]Yates Continuity Correction [d]Fisher's Exact Test *p<0,05 **p<0,01
Group A: Anatomic landmark-guided group, Group U: Ultrasound-guided group

No pneumothorax, hemothorax, catheter embolism, air embolism, skin necrosis, pericardial tamponade was reported. All the rest complications were assigned in Group A.

The mortality rate was significantly higher in Group A (p<0,01). Catheter-related complications such as arrhythmia, vascular thrombosis infection, vein occlusion were detected in Group A, and were significantly higher (p <0.01). Table 3 shows the distribution of catheter-related complications according to the preferences of CVC techniques in detail.

Discussion

CVC is a widely used procedure in emergency departments. To increase successful catheter placement and to reduce procedure-related complications, most guidelines recommend the use of the USG to guide the CVC placement [1-3]. CVC is a procedure that is most of the time is preferred for critical emergency cases: severe hypovolemia, trauma patients, hemorrhage. Some studies report preference of anatomic landmark guided catheterization of a rate of 41- 90 % [1, 4] and ultrasound-guided catheterization of a percentage of 8-32 % [3, 4]. Our rates were 77.72 % and 22.27 %, respectively. In our study, the urgent land-marked CVC indications were mostly patients with acute kidney injury, immediate preparation for hemodialysis, cardiac arrest patients, hypovolemia, and need for central monetarization. The results of our study are similar to the literature. Some studies reported that the main reasons for not using USG to guide the catheterizations were lack of training [5] and the absence of an ultrasound machine [6]. We did not directly query the reason for the preference of the canulisation technique in our study. However, in our research, to understand why physicians prefer or do not prefer ultrasound guides during the central vein catheterization, we investigated the relationship between catheterization technique preference and indications for the central vein catheterization. In our study, we reported that the physicians preferred anatomic landmark guided catheterization for the emergent patients when there is shortness of time for the procedure: the patients such as hypovolemia patients, and to monitor hemodynamic of post-resuscitation patients. And when there is less urgency for the procedure, the ultrasound-guided catheterization was found preferred: e.g., in preparation for hemodialysis. Those results may suggest that physicians are tender to decide that the use of devices during urgency may cause time loss. Preference of the landmark procedure during emergencies (where you do not have the time to wait for the USG, cardiac arrest, for example) also was previously reported in some studies [1]. To establish a decision mechanism for central venous catheterization technique preference, it is necessary to develop procedure algorithms based on time-positive outputs of USG use. Interestingly, some studies believe that physicians should still be able to perform CVC placement without the USG in case of an extremely urgent situation where the physician is unable to wait for the ultrasound machine [1-3]. Such conditions could justify teaching the landmark technique as a rescue technique.

Our study and the results were not specific for certain central vein cannulation. We analyzed all the CVCs independently from the location. Nevertheless, we determined that the jugular vein was most preferred for the central cannulation in both

landmarked and ultrasound-guided techniques with a rate of approximately 94% and 42%, respectively. The subclavian vein was the next preferred location for CVC. Miller et al. reported the femoral approach as most preferred in ED [2]. Clinical trials and reports on central vein cannulation indicate different rates for the preferred vein [3, 4] unless they are not focused on the specific vein cannulation technique.

According to our results, we can argue that physicians seem to prefer immediate intervention to save time in crash emergency cases. However, when we compare and analyze durations of catheter insertion and numbers of attempts of interventions between the groups, we detected that the ultrasound-guided technique saves time: the procedure takes less time, and the intervention is more successful on the first attempt when the ultrasound guide is preferred. Our study reports show that more than 85 % of the patients' intervention duration took less than 20 minutes when ultrasound was used to guide to venipuncture. In the landmark guided group (approximately 62 % of the patients), access and successful insertion took more than 20 minutes. In the ultrasound-guided group, only 14% of the procedures lasted over 20 minutes. Again vein catheterization attempts were made no more than twice using ultrasound, and 94 % of the patients were successfully catheterized at the first attempt, and there was no need for the third attempt when ultrasound is guiding the procedure. When the cannulation was performed landmarked, the success of the process on the first attempt was about 44 %, and more than 17 % of the processes needed more than three attempts. Previous studies report similar high rates (81.3-93.9 %) for a successful first attempt using ultrasonography and variable rates for success using the landmark technique (62-78.5 %) [4-6]. Again, some studies suggest that ultrasonographic guidance leads to a faster insertion time compared with the landmarked technique [1-3].

The possible complications of a technique are as significant as the success rates of the procedure. To compare the landmarked and the ultrasound-guided methods, we investigated the complications and the incidences. The overall complication rate in our study was 20.9% of the total number of cases (i.e. 46 cases out of 220). All complications (45 cases) were reported after landmarked cannulation. The most common complications we established in our study were catheter infection, arrhythmia, vein obstruction, and thrombosis. Most studies report fewer complications with ultrasound use [1, 4-7].

The anatomically guided technique may lead to more complications because an increase in the number of insertion attempts is associated with a higher complication rate. The incidence of complications in our study is relatively low.

Our study results will contribute to the literature, as there are only a few studies on central venous access techniques in the ED.

Study Limitations

The current study has several limitations. First of all, the fact that the study was not multi-centered is an important limitation. However, it was performed in high-volume emergency departments and all consecutive patients meeting the criteria were included, thereby limiting selection bias. Secondly, the number of patients was limited; we think that further studies with a larger number of patients will add significance to this subject.

Conclusion

We found a significant increase in the success rate and a significant decrease in the complications rate and intervention duration, when the ultrasound-guided technique is preferred for central vein cannulation compared with the landmark technique. When ultrasonography is available, ultrasonographically-guided procedure should become the standard of cannulation procedure in ED.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. Denys BG, Uretsky BF, Reddy PS. Ultrasound-assisted cannulation of the internal jugular vein. A prospective comparison to the external landmark-guided technique. Circulation. 1993; 87(5): 1557-62.

2. Mariantina F, Gravvanis A, Dimitriou V, Papalois A, Kouraklis G, Karabinis A et al. Real-time ultrasound-guided subclavian vein cannulation versus the landmark method in critical care patients: a prospective randomized study. Crit Care Med. 2011; 39(7): 1607-12.

3. Maizel J, Bastide MA, Richecoeur J, Frenoy E, Lemaire C, Sauneuf B, et al. Practice of ultrasound-guided central venous catheter technique by the French intensivisits: a survey from the BoReal study group. Ann Intensive Care. 2016;6(1): 76.

4. Ullman AJ, Marsh N, Mihala G, Cooke M, Rickard CM.Complications of central venous Access devices: a systematic review. Pediatrics, 2015; 136(5):e1331-e44.

5. Calvache JA, Rodríguez MV, Trochez A, Klimek M, Stolker RJ, Lesaffre E. Incidence of mechanical complications of central venous catheterization using landmark technique: do not try more than 3 times. J Intensive Care Med. 2016;31(6): 397-402.

6. Leung J, Duffy M, Finckh A. Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. Ann Emerg Med. 2006; 48(5):540-7.

7. Dudeck O, Teichgrager U, Podrabsky P, Haenninen EL, Soerensen R, Ricke J. A randomized trial assessing the value of ultrasound-guided puncture of the femoral artery for interventional investigations. Int J Cardiovasc Imaging. 2004;20 (5): 363-8.

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